Cluster Tree Power Aware Routing Protocol for WSN (CTPA)

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***Abstract*— Sensor webs consisting of nodes with limited battery power and wireless communications are deployed to collect useful information from the field. Gathering sensed information in an energy efficient manner is critical to operate the sensor network for a long period of time. Sensor webs consisting of nodes with limited battery power and wireless communications are deployed to collect useful information from the field. Gathering sensed information in an energy efficient manner is critical to operate the sensor network for a long period of time. Three major factors that affect data aggregation in wireless sensor networks are Network lifetime , Scalability and load balancing. Thus there are many existing work on energy efficient data gathering in wireless sensor networks like Pegasis, Leech and Treepsi. In this paper we have proposed a new energy efficient cluster based protocol that combines features of both Trees based and Cluster based architecture.**

Keywords- Wireless Sensor Networks(WSNs; Energy efficient; Cluster head.

I. INTRODUCTION

Advances in sensor technology, low-power electronics, and low-power radio frequency (RF) design have enabled the development of small, relatively inexpensive and low-power sensors, called micro sensors, which can be connected via a wireless network [1, 2, 3].They also are supplied with transceivers to gather information from its environment and pass it on up to a certain base station, where the measured parameters can be stored and available for the end user. In most cases, the sensors forming these networks are deployed randomly and left unattended to and are expected to perform their mission properly and efficiently. As a result of this random deployment, the WSN has usually varying degrees of node density along its area. Sensor networks are also energy constrained since the individual sensors, which the network formed with, are extremely energy constrained as well. The communication devices on these sensors are small and have limited power and range. Both the probably difference of node density among some regions of the network and the energy constraint of the sensor nodes cause nodes slowly die making the network less dense. Also it is quite common to deploy WSNs in harsh environment, what makes many sensors inoperable or faulty. For that reason, these networks need to be fault-tolerant so that the need for maintenance is minimized. Typically the network topology is continuously and dynamically changing, and it is actually not a desired solution to replenish it by infusing new sensors instead the depleted ones. A real and appropriate solution for this problem is to implement routing protocols that perform efficiently and utilizing the less amount of energy as possible for the communication among nodes. Since battery replacement is not an option for networks with thousands of physically embedded nodes, an efficient energy saving protocol is required to prolong the sensor network lifetime. Generally speaking, more the sensors close to circumstance, the more sensed information is precise when sensor are sensing events. For this reason, sensor nodes always are disposed plenty and densely in the sensing field. a lot of routing protocols are purposed to improve the power consumption in wireless sensor networks [8, 9]. A growing number of technologies are now available to produce a sensor node whose volume is limited in few cubic centimeters [2]. Network lifetime can be defined as the time elapsed from the network operation starts until the first node (or the last node) in the network depletes its energy (dies). Energy consumption in a node can be due to either useful or wasteful operations. The useful energy consumption includes transmitting or receiving data messages, and processing query requests. On the other hand, the wasteful consumption can be due to overhearing, retransmitting because of harsh environment, dealing with the redundant broadcast overhead messages, as well as idle listening to the media. In order to save the transmission power, clustering [5, 6], and multi-hop transmission techniques can be used. Adjacent sensors may sense the same data and therefore the data gathering can reduce the redundant data collection. Sensors close to each other in the network can be grouped into clusters and data obtained from sensors in the same cluster are aggregated and then reported to the base station (BS), data report to the BS can be performed by single hop or multi-hop transmission.

TABLE I. TYPES OF PROTOCOLS

PROTOCOL TYPE	FEATURES
Cluster based	Nodes divides several clusters for cluster head sending
Chain based	Nodes forming long chain for chain head fuse
Tree based	Build a tree like path for root node aggregation

II. RELATED WORK

In general, Wireless Sensor Networks (WSNs) can gather the sensed information by hundreds or even thousands of sensing nodes and transmit them to the sink. It uses the easiest way that sensor nodes transmit the sensed data to sink directly. Using this way is very simple, but it will have a serious problem. When a farther sensor node transmits the data, it will spend more energy than the closer one. Therefore, it is desirable to make these nodes as energy-efficient as possible and to rely on their large numbers in order to obtain high quality results. Likewise, the sensor network routing protocols must be designed to achieve fault tolerance in the presence of individual node failures while also minimizing energy consumption. Moreover, since the limited wireless channel bandwidth must be shared by all the sensors in the network, routing protocols for these networks should be able to perform local collaborations in order to reduce the bandwidth requirements. Eventually, the data being sensed by the nodes in the network must be transmitted to a control center (i.e., the sink) or base station where the end sensor nodes can access the data. At present, there are many routing methods in the wireless sensor networks [8, 9].

TABLE II. FEATURES OF VARIOUS PROTOCOLS

ATTRRIBUTES	LEACH	PEGASIS	TREEPSI
Computation	Compare signal strength of cluster head periodically	Select chain head with greedy algorithm	Select root head with standard tree algorithm
Framework	Cluster head	Chain based	Tree based
Aggregation	Store Cluster head	Store two neighbors	Fusion in each node

A. LEACH

In [5], authors proposed a Low-Energy Adaptive clustering Hierarchy (LEACH) protocol. LEACH is representative cluster-based of routing protocols. It is also the first proposed in wireless sensor network and can reduce power consumption on avoiding the communication directly between sink and sensor nodes. In a sensor field, sensor node senses data and sends data to the sink that called round. The working procedure for LEACH will be finished in a round. Before gathering the sensed data at each round, the huge number of sensor nodes will divide into several clusters and choose a cluster head randomly by self organization. Each cluster head is in charge of gather the sensed data from the sensor nodes in the cluster.. The cluster head will aggregate the received data, and then send to the sink directly. After sink received all the data from cluster heads, a round will be ending. There are two phases in each round about LEACH, Setup phase and Steady-state phase. This phase consists of two major steps: cluster formation and cluster head selection. Once the base station forms the primal clusters, they will not change much because all sensor nodes are immobile, whereas the selected cluster head in the same cluster may be different in each round. During the first round, the base station first splits the network into two sub clusters, and proceeds further by splitting the sub clusters into smaller clusters. The base station repeats the cluster splitting process until the desired number of clusters is attained. When the splitting algorithm is completed, the base station will select a cluster head for each cluster according to the location information of the nodes. For a node to be a cluster head, it has to locate at the center of a cluster. Once a node is selected to be a cluster head, it broadcasts a message in the network and invites the other nodes to join its cluster. The other nodes will choose their own cluster heads and send join messages according to the power of the many received broadcast messages. When the cluster head receives the join message from its neighbor node, it assigns the node a time slot to transmit data. When the first round is over and the primal cluster topology is formed, the base station is no longer responsible for selecting the cluster head. The task of cluster formation is shifted from the base station to the sensor nodes. The decision to become a new cluster head is made locally within each cluster based on the node's weight value.

B. PEGASIS

In [6, 7], authors proposed a Power-Efficient Gathering in Sensor Information Systems (PEGASIS). PEGASIS is based on chain-based protocol and differ from LEACH. This proposal is building all sensor nodes to form a chain according to Greedy algorithm that the sum of edges must be minimum in wireless sensor networks. At the initial phase before each round, they must choose a chain head. The N represents the number of nodes and all the nodes use the natural number from 1 to N. Then WSNs utilize the i = j mod N to choose chain head. If it is equal to zero, then choose N. The two end-point of the chain will start send sensed data to the parent's nodes for forwarding data to the chain head. All the nodes in the chain only transmit data to its neighbor. Each edge only sends or receives data one time. In [6], after the chain head received the two children nodes, it will aggregate the data and transmit the collecting data to sink directly.

C. TREEPSI

In [4], authors proposed a Tree-based Efficient Protocol for Sensor Information (TREEPSI). TREEPSI is tree-based protocol that is different from above mentioned protocols. Before data transmission phase, WSNs will select a root node in all the sensor nodes. Set the root identify id=j. There are two ways to build the tree path. One is computing the path centrally by sink and broadcasting the path information to network. The other can be the same tree structure locally by using a common algorithm in each node. At the initial phase, root will create data gathering process to the children nodes using any standard tree traversal algorithm. The go into the data transmission phase after building the tree. All the leaf nodes will start sending the sensed data towards their parent nodes. The parent nodes will collect the received data with their own data. Then send the collected data to their parent. The transmission process will be repeated until all the received by the root node. After root node aggregating data, it send collecting data to sink directly. The process will go around until the root node dead. WSN will re-select a new root node. Root id number would be j+1. Then do the initial phase again like above. The tree path will not change until the root node dead. TREEPSI and PEGASIS are using the same way to transmit data from leaf node to chain/root head. The length of path form end leaf node to root/chain node in TREEPSI is shorter than PEGASIS. The data will not send data for a long path. For this reason, TREEPSI can reduce power consumption less in data transmission than PEGASIS. The TREEPSSI has

better performance about 30% than PEGASIS. It still has a problem that restriction on the binary tree algorithm, the path has made a detour in the topology.

III. PROPOSED WORK

In terms of energy efficiency a tree based protocol is better than a cluster based protocol .So if some sensor nodes need to send data to the base station then that information may not be accurate enough or the send data will make a deviation from the exact information. Thus more power will be dissipated in this process. This situation is happened as building the binary tree paths, especially when the sensor field is large and the numbers of\ sensor nodes are large. So our primary goal is to restrict the energy dissipation in the network so in order to reduce the power dissipation we propose a new protocol that combines the features of Tree based architecture as well as the cluster based technique .We call our proposed protocol as CTPA data aggregation routing protocol. Below is described the proper description of the protocol in detail. The network assumptions can be initiated as follows [4, 5, and 6].

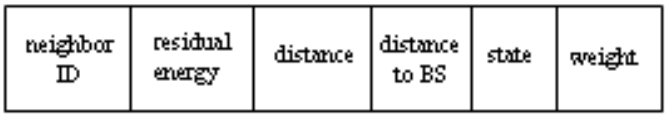

Figure 1. Neighbor Table & Information Table

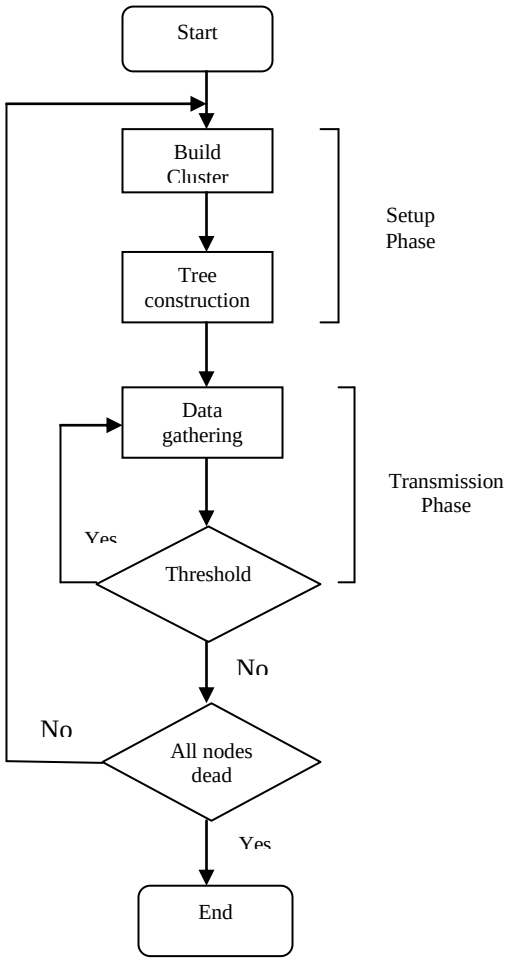

Figure 2. Flowchart of CTPA

1. Each node or sink has ability to transmit message to any other node and sink directly.
2. Each sensor node has radio power control node can tune the magnitude according to the transmission distance.
3. Each sensor node has the same initial power in WSNs.
4. Each sensor node has location information.
5. Every sensor nodes are fixed after they were deployed.
6. WSNs would not be maintained by humans.
7. Every sensor nodes have the same process and communication ability in WSNs, and they play the same role.
8. Wireless sensor nodes are deployed densely and randomly in sensor field

Sink could get the whole location and energy information about sensor nodes by two or other manners. One is recorded in the sink at the initial state as nodes were deployed. The other is that sink broadcast whole network, and then received the back message form sensor nodes. Basically there are three phases in our proposed protocol.

1. *Cluster formation*
2. *Building cluster based tree*
3. *Data aggregation*

A. CLUSTER INFORMATION

This phase constitutes two sub phases: setting clusters and selection of cluster head. Once the base station forms the primal clusters, they will not change much because all sensor nodes are immobile, whereas the selected cluster head in the same cluster may be different in each round. During the first round, the base station first splits the network into two sub clusters, and proceeds further by splitting the sub clusters into smaller clusters. The base station repeats the cluster splitting process until the desired number of clusters is attained. When the splitting algorithm is completed, the base station will select a cluster head for each cluster according to the location information of the nodes. For a node to be a cluster head, it has to locate at the center of a cluster. Once a node is selected to be a cluster head, it broadcasts a message in the network and invites the other nodes to join its cluster. The other nodes will choose their own cluster heads and send join messages according to the power of the many received broadcast messages. When the cluster head receives the join message from its neighbor node, it assigns the node a time slot to transmit data. When the first round is over and the primal cluster topology is formed, the base station is no longer responsible for selecting the cluster head. The task of cluster formation is shifted from the base station to the sensor nodes. The decision to become a new cluster head is made locally within each cluster based on the node's weight value.

PSEUDOCODE

INIT

1. *Sink determines the number of clusters(N) to be formed*
2. *Split the network into N clusters*
3. *Select cluster head from each cluster*

ITERATE

1. *If a node i receives notify msg from sink node it works in cluster head mode*
2. *If it receives a broadcast msg from cluster head it works in sensing mode*

FOR A CLUSTER HEAD NODE(i)

1. *Receive data from cluster member j*
2. *Compute weight value Wi and Wj*
3. *If Wi > Wj then node I is the new cluster head*
4. *Else node I work in sensing node and node j is the cluster head*

B. BUILDING CLUSTER BASED TREE

Sink will collect the information that cluster head had labeled in each cluster and build path in minimum spanning tree to compute the tree path. The Minimum Spanning tree (MST) concept in the Greedy algorithms used to solve the undirected weight graph problem. After eliminating some of the connection links, the sub-graph still have the connection ability. For this reason, sub-graph can reduce the sum of the weights. A sub-graph who has the minimum sum of weights must be a tree like framework. Spanning tree could let all nodes conform to tree definition which is connected in the graph. A connected sub-graph which has a minimum sum of weights must be a spanning tree.Generally Prim's algorithm is applicable to build MST.

C. DATA AGGREGATION

After the routing mechanism has established, every tip nodes transmit gathering data to upper level nodes. Then the upper level nodes will fuse received data and sensed data by itself, and send the data to next upper level nodes. The process will keep going until the root node, cluster head, has aggregated the data in the cluster. It is called a round as all root nodes has finished transmitting data.

D. BUFFER MECHANISM

Apart from these stages it provides an additional advantage in the form of a buffer in store .Every cluster head node has a buffer associated with them which stores the recently accesed queries and their results .When a query reaches a particular cluster head node it first checks whether that query already exists or not . If it exists it retrieves its results and get the results without further traversing the individual nodes of the clusters. But if it does not exist it traverses all the individual sensor nodes in all the clusters let us consider an example by taking the query as "Find the average temperature of the room " . Now when this query is fired it first reaches the sink node and it broadcasts that query in the entire network .When it reaches the cluster heads of the clusters these cluster heads checks if they have any related information and suppose one of the cluster head finds the results of a recently accessed query that computes the summation of the temperature of that cluster then that query need not have to traverse in that cluster since the cluster head has the predefined information about the number of nodes in its cluster .Thus it ignores this particular cluster and moves to other In this way instead of traversing the entire network the query may leave out some sensor nodes if the cluster head of a cluster provides some relevant information. Thus it helps in improving the response time of the sensor nodes and prevents every node to be processed individually thereby minimizing the energy consumption in the network .Thus this buffer mechanism acts like a catche that speed up the data transmission and aggregation process.

Features of Buffered Mechanism

1. It acts as temporary storage that guides the routing path for a query.
2. Response time is fast.
3. There is no need to traverse the entire Tree based network if the result is available in the cluster head nodes only.
4. Energy consumption in the entire network is minimum since related results are available in the cluster head so there is no need for a query to visit through all the nodes in the entire network.
5. Query execution time is faster.
6. High availability of data in the network.

IV. CONCLUSION

In our work a new protocol has been introduced for wireless sensor. Our proposed method has several advantages in WSNs for data gathering. It reduces power consumption on avoiding the communication directly between sink and sensor nodes. Use of threshold mechanism, also increase the number of nodes alive, means it increase the network lifetime as compare to others. It protected the parent node death slowly, because each node has chances to be parent. Our clustered-tree based data gathering protocol works on three phases. With the help of first phase, we have maximized the network life time by balancing the energy consumption of nodes. And second phase we have reduced the communication overhead by forming tree structure. Finally the third phase consists of the buffered technique with the help of which the response time and the execution time of a query is significantly reduced. Thus our proposed model is an efficient data aggregation scheme.

REFERENCES

[1] R. Min, M, Bhardwaj, S. Cho, A. Sinha, E. Shih, A. Wang, and A. P. Chandrakasan, Low Power Wireless Sensor Networks, Proceedings of International Conference, Bangalore, India, January 2001.

[2] J. M.Rabaey, M. J.Ammer, J. L. da Silva Jr., D. Patel, S. Roundy, Pico Radio supports ad hoc ultra low power wireless networking,IEEE Computer, Vol. 33, pp. 42-48, July 2000

[3] K. Sohrabi, J. Gao, V. Ailawadhi, and G. Pottie., Protocols for selforganization of a wireless sensor network, IEEE Personal Communications, Vol. 7, No. 5, pp. 16-27, October 2000.

[4] S.S. Satapathy and N. Sarma ,TREEPSI: tree based energy efficient protocol for sensor information ,Wireless and Optical Communications Networks 2006, IFIP International Conference 11-13 April 2006 .

[5] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, Energy-Efficient Communication Protocol for Wireless Microsensor Networks, Proc. Hawaii Conf. System Sciences, Jan. 2000.

[6] S. Lindsey, C. Raghavendra and K. M. Sivalingam, Data Gathering Algorithms in Sensor Networks Using Energy Metrics, IEEE Transactions On Parallel and Distributed Systems, Vol . 13, No. 9, September 2002.PEGASIS

[7] S. Lindsey, C. Raghavendra,Pegasis: Power-Efficient gathering in sensor information systems, In: Proc. of the IEEE Aerospace Conference, 2002. Pp.1-6.

[8] Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, —A survey on Sensor Networks,IEEE Communications Magazine, vol. 40, Issue: 8, pp. 102- 114, August 2002.

[9] Q. Jiang and D. Manivannan , —Routing Protocols for Sensor Networks, IEEE Consumer Communications and Networking Conference, 2004.